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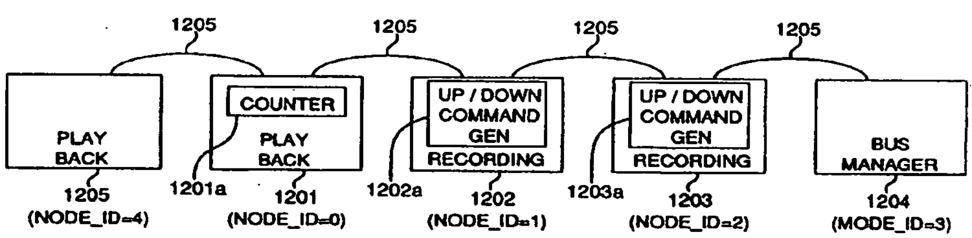
(54) Data transmission system and method.

(57) The data transmission method employs IEEE P1394 protocol. The data header of the transmitted isochronous packet is added with a node identifier identifying the transmitter node, so that the receiver node can immediately identify the transmitter node, and can thereby request the transmitter node to maintain transmission. A Broadcast channel is a default channel used for isochronous packet transmission, unless a different channel number is otherwise specified. Thus, it is not necessary for the user to coordinate the channel number used by the transmitting and receiver nodes. It is also not necessary for the transmitter node to notify the receiver node, or the receiver node to notify the transmitter node, of the channel number used.

Fig.8



BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a system for transmitting audio signals and/or video signals as a digital signal in such applications as a digital video cassette recorder (VCR) whereby audio signals and/or video signals are recorded and reproduced as digital signals, and also to a method thereof.

2. Description of the prior art

Devices for transmitting audio signals and/or video signals via a digital signal transmission path are being continually developed. Transmitting audio signals and/or video signals as a digital signal, however, requires sending and receiving to be synchronized to the processing speed of the apparatus, and therefore requires a transmission path capable of isochronous transmission. A bus connection is even more preferable considering the potential need for two-way communications on a single transmission path whereby plural devices can receive a signal transmitted from a single device.

The Institute of Electrical and Electronic Engineers, Inc. (IEEE) is currently studying a next-generation high speed serial bus protocol under the title P1394 (see "High Performance Serial Bus"). Under the proposed IEEE P1394 standard, isochronous transmission data, including audio signals, video signals, and other real-time data, can be transmitted by isochronous transmission using isochronous packets, which are sent and received every 125 µsec (= 1 cycle) to achieve isochronous transmission.

The isochronous transmission control method of IEEE P1394 is described next. When the bus is initialized according to IEEE P1394, a node identifier is automatically assigned to each device connected to the bus (each 'node') as a means of identifying each node. A maximum 64 isochronous packets per cycle can also be sent over the bus. As a result, each isochronous packet is also assigned a channel number ranging in value from 0 to 63 to identify each isochronous packet. To achieve isochronous transmission on plural channels, one of the plural nodes connected to the bus is used for isochronous transmission management; this node is called the "bus manager" below.

The bus manager manages the channel numbers used for isochronous transmission, and the time remaining in each cycle usable for isochronous transmission. The time sharing rate, or the time slot width, required for each node to transmit an isochronous packet in one cycle is referred to as a bandwidth below. To achieve isochronous transmission, the bus manager must reserve the channel number and the bandwidth to be used. It should be noted that communications not essential to isochronous transmission and information that does not require isochronous transmission are transmitted by asynchronous transmission using asynchronous packets. Asynchronous communication is accomplished using cycle time not used for isochronous transmission.

The bus is also immediately reinitialized whenever a node is connected or disconnected from the bus, or whenever any node on the bus is turned off, to enable active bus configuration.

The first problem addressed by the present invention is described next.

When the IEEE P1394 high performance serial bus is applied to isochronous transmission between consumer audio-visual (A/V) devices using the conventional isochronous packet described above, it is not possible for the node receiving the isochronous packet to identify the node sending that isochronous packet.

Because of this node identification problem, the node receiving the isochronous packet cannot request the node sending the isochronous packet to continue isochronous packet transmission when it is necessary to prevent interruption of isochronous transmission due to an unexpected user action, and it is therefore not possible to set the transmission node to a protected state.

This is described below referring to a system comprising nodes A, B, and C with node B assumed to be receiving and recording the isochronous packet sent by node A. If the user then performs some action causing node C to transmit an isochronous packet, node C must request node A to stop transmitting the isochronous packet. If node A responds to this request by stopping transmission, the recording operation of node B will be interrupted. It is therefore possible by this conventional data transmission method to interrupt the transmission of isochronous packets between communicating nodes when one node not associated with that isochronous packet transmission is accidentally or improperly operated.

The second problem is described next. As described above, the IEEE P1394 protocol enables plural channels of real-time data to be output during one cycle. It is therefore necessary for the receiver node(s) to determine the channel numbers of the real-time data that should be received by that node. One method of enabling the receiver node to determine the channel numbers to be received is for the user to inform the receiver node of the channel numbers to be received. To do this, however, the user must determine and inform the receiver node of the channel numbers of the real-time data that should be received, and this in-

Fig. 16 is a flow chart of the communications management block when transmission is stopped by the third embodiment of the invention;
Fig. 17 is a flow chart of the communications management block when transmission is started by the fourth embodiment of the invention;
Fig. 18 is a flow chart of the communications management block when transmission is stopped by the fourth embodiment of the invention;
Fig. 19 is a flow chart of the communications management block when isochronous transmission to another node is commanded by the fifth embodiment of the invention; and
Figs. 20 and 21 are flow charts of the communications management block when isochronous transmission is commanded by another node according to the fifth embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention relates to a transmission procedure for transmitting real-time data such as audio/visual data using the P1394 protocol currently being considered by the Institute of Electrical and Electronic Engineers, Inc. Fig. 1 shows a plurality of audio/visual devices connected to a bus according to the IEEE P1394 protocol. In this example, four audio/visual devices are connected to a common bus, and the devices are referred to as nodes. A/V devices 101, 102, 103, and 104 are connected by a cable 105 which serves as a bus structure.

The A/V devices 101 - 104 have a similar control arrangement which is shown in Fig. 2 by way of example for A/V device 102. Each A/V device comprises an interface block 201, an A/V signal processing block 202, and a control block 203. Signals from the other nodes are input to one A/V device 102 through the interface block 201. In the interface block 201, the input signals have their waveform shaped, and the waveform-shaped signals are output to the next A/V device 103. The interface block 201 is capable of transmitting the output signals from any other A/V device, i.e., any other node when connected according to the IEEE P1394 protocol as shown in Fig. 1, to all other A/V devices (nodes).

In the IEEE P1394 protocol, real-time data is transmitted using isochronous packets, the format of which is shown in Fig. 3 as defined by IEEE P1394.

Each isochronous packet comprises a 4-byte packet header 301; a 4-byte header CRC 302 for checking for transmission errors in the packet header 301; a data block 303; and a 4-byte data CRC 304 for checking for transmission errors in the real-time data.

The format of the packet header 301 is shown in Fig. 4. As shown in Fig. 4, the packet header 301 includes the channel number 401. According to the IEEE P1394 protocol, plural A/V devices (nodes) can transmit plural isochronous packets on a time-share basis approximately every 125 µsec (= 1 cycle). The channel number 401 is added to the isochronous packets for identifying each packet transmitted during the same cycle.

When transmitting real-time data, the control block 203 instructs the A/V signal processing block 202 to output the real-time data, including the audio/visual data. Based on the instructions from the control block 203, the A/V signal processing block 202 therefore outputs the real-time data. The control block 203 also adds the channel number used and other information, and controls isochronous packet output to the interface block 201.

Based on the instructions from the control block 203, the interface block 201 packetizes the real-time data from the A/V signal processing block 202 as the data block 303 shown in Fig. 3 according to the packet format also shown in Fig. 3. The interface block 201 then outputs the isochronous packet to the other nodes (A/V devices).

When receiving real-time data, the control block 203 informs the interface block 201 of the channel number of the isochronous packets to be received. The interface block 201 then detects the channel number of each isochronous packet from the packet header. If the detected channel number is the specified channel number, the interface block 201 outputs to the A/V signal processing block 202 the real-time data contained in the data block 303 from the isochronous packet shown in Fig. 3. The control block 203 also controls input of the real-time data to the A/V signal processing block 202, which signal processes the input data.

It is therefore possible for plural nodes to transmit plural isochronous packets during the same cycle by the IEEE P1394 protocol as described above, i.e., plural isochronous transmission between plural nodes can be accomplished in an apparently simultaneous manner. It is necessary, however, to reserve sufficient bandwidth for the internal processing speed of each node with each isochronous transmission. Here, the bandwidth means a width of a reserved time slot in each cycle of 125 µsec, and various time slots in each cycle are distinguished by different channel numbers. According to the IEEE P1394 protocol, it is possible to use, at the maximum, 64 different channel numbers, from 0 to 63. Because the maximum transmittable bandwidth is limited (obviously less than 125 µsec), it is necessary to manage the bandwidth used by each node. In addition, a channel number is added to each isochronous packet to identify each isochronous packet and thereby en-

able isochronous transmission of data on plural channels. Managing the channel numbers used by each node is necessary to prevent the same channel number from being assigned to packets on different channels when plural nodes simultaneously output isochronous packets. This channel number duplication is prevented in the IEEE P1394 protocol by dedicating one node as a bus manager for centrally controlling bandwidth and channel numbers. A/V devices or other node devices executing isochronous transmission must receive from the bus manager the specific bandwidth and channel number used by that node for isochronous transmission. Note that the "used bandwidth" defines the amount of time in each cycle that the node outputting the isochronous packet can monopolize the bus to send the isochronous packets.

Communications other than the isochronous transmission described above, e.g., communications for obtaining the used bandwidth and channel number, are accomplished by asynchronous transmission using asynchronous packets. Asynchronous transmission is accomplished using the cycle time remaining after isochronous transmission is completed in each cycle. Fig. 5 shows the asynchronous packet format defined by IEEE P1394.

Each asynchronous packet comprises a 16-byte packet header 501; a 4-byte header CRC 502 for checking for transmission errors in the packet header 501; an asynchronous data body 503; and a 4-byte data CRC 504 for checking for transmission errors in the asynchronous transmission data. The packet header 501 comprises a receiver node identifier 601, which is the identifier of the node to which the transmitted asynchronous packet is addressed, and a transmitter node identifier 602, which is the identifier of the node transmitting the packet. The receiver node identifier 601 and the transmitter node identifier 602 in the packet header are each two bytes long. The receiver node receives all asynchronous packets in which the value of the receiver node identifier 601 is equal to the node identifier of the receiver node. The receiver node can also determine by the transmitter node identifier 602 in the received asynchronous packets which node sent the asynchronous packet by reading the transmitter node identifier 602.

The procedure for asynchronous transmission is described next. To send an asynchronous packet, the control block 203 instructs the interface block 201 to asynchronously transmit the asynchronous transmission data after appending the receiver node identifier identifying the addressed node. The interface block 201 thus generates and outputs the asynchronous packets from the asynchronous data, receiver node identifier, and other information input from the control block 203. When an asynchronous packet is received, the interface block 201 identifies the asynchronous packets addressed to that node by evaluating the receiver node identifier 601 contained in the packet header 501, and outputs the asynchronous data 503 and the transmitter node identifier 602 from the received asynchronous packet to the control block 203. The control block 203 then executes the required processing based on the asynchronous data input thereto.

Referring to Figs. 7 to 10, the first embodiment of the present invention is described below. Note that the first embodiment is described with specific application to a video cassette recorder (VCR) as the A/V device.

Fig. 7 shows the format of an isochronous packet transmitted during isochronous transmission by the first embodiment of the invention.

Referring to Fig. 7, data block 303 is used to communicate any data the user wishes to communicate, and comprises a data header 702 identifying the type of data transmitted in that isochronous packet, and the A/V data 703 actually transmitted. The data header 702 comprises the node identifier 1101 identifying the node that transmitted that isochronous packet, and other header data. Thus, by detecting and reading the node identifier 1101 at the receiver node, it is possible to detect who is the transmitter node.

When a new node is connected and a bus reset is generated according to the IEEE P1394 protocol, a new node identifier is automatically assigned to that newly connected node. As a result, the node transmitting the isochronous packet writes the node identifier assigned thereto to the data header 702 according to the format shown in Fig. 7, and then transmits the isochronous packet.

Fig. 8 shows how five VCRs may be connected for dubbing A/V data. The operation of each of the five VCRs 1201 - 1205 is controlled by the control block 203 built in to each VCR. Note that the control block 203 of the present invention is achieved by a microcomputer. The VCRs 1201 - 1205 are connected by connector cables 1205. Each time a cable is connected, a 'bus reset' command is generated to assign the node identifiers to the VCRs 1201 - 1205. Node identifiers (node_ID) 0 - 4 are assigned to VCRs 1201 - 1205, respectively, by way of example only in the following description.

As noted above, packet sending and receiving is executed on a 125 μsec cycle according to the IEEE P1394 protocol, and the first half of each cycle can be assigned to a priority time band for isochronous transmission. It is therefore necessary to reserve the bandwidth required within the finite priority time band reserved for isochronous transmission. More specifically, it is necessary to first determine which communications channel is to be